As shown in the table, resultant speeds at these four stations agree rather closely, except in the lower levels, where they are somewhat greater at Lansing and Royal Center than at Drexel and Ellendale. A point well brought out by the figures is the latitudinal variation in resultant direction, the north component increasing with latitude and being quite pronounced at Ellendale, where it persists at all altitudes. At Royal Center a south component is found, although it is small in the upper levels. There are, of course, seasonal variations, the north component being strongest in winter, and weakest in summer. Seasonal values have not yet been computed for Lansing, but they have been published for the other three stations.[2]

[2] An Aerological Survey of the United States, Part I. Results of observations by means of kites, Mo. WEATHER REV. Supplement No. 20, Table 4, 1922.

RELATION OF CROP YIELDS TO QUANTITY OF IRRIGATION WATER IN SOUTHWESTERN KANSAS.

By J. B. KINCER.

[Review of Bulletin 228, Kansas Agricultural Experiment Station.]

While Kansas is one of our leading agricultural States, the more western portion usually receives rather scanty rainfall. The 20-inch annual isohyet extends across the State in a north-south direction about 60 miles from the western border, which means that some 7,000,000 acres of land receive less than 20 inches of precipitation annually. This amount of rainfall is usually considered about the minimum necessary for successful farming under ordinary cultural methods and, consequently, in extreme western Kansas, farming is more or less precarious from the standpoint of returns, unless special methods are employed for artificially supplying or conserving soil moisture.

Up to the present time irrigation has not been practiced in this section to any great extent, although nearly 100,000 acres are so treated, about 80 per cent being in Finney and Kearny Counties through which the Arkansas River flows. Owing to the existence of large supplies of readily available underground water, however, especially in the southwestern portion of the State, it is quite likely that irrigation at some future time may be practiced very extensively. In view of this, the Kansas Agricultural Experiment Station is maintaining at Garden City, Finney County, a branch station chiefly for experimental purposes to secure information applicable to both present and prospective irrigation problems.

There are two questions of primary interest to every irrigation farmer: (1) The kind of crops best suited to irrigation farming, and (2) the most economical amounts of water to apply. To aid in answering these a series of experiments was started by the branch station at Garden City in 1914 and continued for five years, under the supervision of Mr. George S. Knapp, superintendent. The results are set forth in Bulletin 228, Agricultural Experiment Station, Manhattan, Kans., and may be briefly reviewed as follows:

Experiments were conducted with seven crops, including milo, kafir, sumac, Sudan grass, wheat, oats, and barley, grown in duplicate series on plats containing one-twentieth of an acre. Each crop was grown on four plats, designated, "A," "B," "C," and "D," each of which received a different amount of water. All plats were irrigated during the winter, and in addition, the A plats were irrigated sufficiently during the summer to maintain the moisture content of the soil at about 20 per cent; the B plats at about 16 per cent, and the C plats at about 12 per cent. The D plats were not irrigated during the growing season. Because of the seasonal variation of rainfall and a lack of knowledge concerning the amount of water actually required by the crop under test, the moisture content of the soil was determined at intervals as a basis for the application of water. Whenever the moisture content dropped a few points below the predetermined condition for a given plat, water was applied in sufficient quantity to raise the moisture content a few points above the fixed amount. From 2 to 4 inches of water were applied at each irrigation.

Five-year average productions for milo grain were: Plat A, 53.7 bushels; B, 47.3; C, 40.7; and D, 15.3. While each increase in the amount of water showed a definite increase in yield, the greatest difference was between the D and C series, where an increase of 4.1 inches, or 47 per cent of the amount of water applied increased the yield 22.4 bushels, or 146 per cent.

In the case of kafir, the amounts of water required to maintain the soil moisture were almost the same as for milo, but the yields were not so large and showed a smaller range on the different plats. The yields in like serial order were 33.7, 29.6, 23.8, and 13.3. While these results in the main agree with those for milo, there was a less definite response with increased application of water, from which it appears that kafir is not so productive a crop as milo to raise under irrigation, unless produced for forage as well as grain.

In general, the response of sumac to water was about the same as for milo and kafir, although the conclusions are quite different, because this crop is used primarily more for forage than for grain. There was a gradual increase in the amount of forage, but the difference was not great in the three plats receiving water during the growing season. Throughout the experiment, it was observed that the sorghum crops most plentifully supplied with water invariably matured earliest. This appeared to be due to the plants becoming dormant when moisture was deficient and resuming growth when water was applied, while those receiving sufficient moisture made continuous growth and consequently matured earlier.

One of the most striking results with Sudan grass was its failure to respond significantly to increased quantities of water in both seed and stover. There was a slight increase in the yield of stover, but it was very small compared with the amount of water used. It might be supposed that the lack of response to increased water indicates a small water requirement of the crop, but at the same time more water was necessary to maintain the soil moisture at the required degree than for any other sorghum crop in the experiment, which would indicate that it took up water more rapidly than the others. The grass was planted in rows, however, and it is probable that had it been drilled and harvested as a hay crop, the yield of hay would have been much larger and there would probably have been a wider variation for the different plats.

In the case of wheat, there was in general an increase in yield with increased application of water, but there were large variations in yield from year to year, notwithstanding the soil moisture was maintained at an approximately uniform degree. Mr. Knapp concludes from this that wheat yields were influenced nearly as much by general weather conditions during the growing season as by soil moisture; that no amount of water would insure good yields in unfavorable years; that increasing the amount of water has little effect on yield, and that very little is to be gained by the application of more than 10 inches of irrigation water. The five-year averages show for the D plats, 13.4 bushels per acre; C, 19.3; B, 19.1; and A, 21.8. The results with oats and barley corresponded in general with those for wheat.

It is of interest to note the amount of irrigation water required to maintain the respective plats at the predetermined moisture content and the relation these amounts bore to the rainfall and winter irrigation. The latter was governed by soil conditions and varied somewhat from year to year, but in general amounted to about 8 inches, that is, the depth to which the water applied would have covered the land if there had been no percolation. The five-year average required during the growing season to maintain the soil moisture at 12 per cent was about 2.5 inches for the sorghums and about 2 inches for the grains. For the 16 per cent moisture plats, the requirement was about 7 and 7.5 inches, respectively, and for those maintained at 20 per cent, about 13 and 14 inches.

The amounts required in individual years, however, varied greatly from these averages, but they show a very close relation to the amount of winter precipitation. The period covered is so short that a statistical correlation between the several variants could not be considered of much significance, but the relation shown between the amount of irrigation required during the growing season and the precipitation during the preceding fall and winter months is remarkable and the lack of relation between the irrigation water and summer rainfall is surprising. If we combine the three sorghum crops, milo, kafir, and sumac, and count the total number of plats in a given series of each, we have 15 values for comparison. In this case the relation, for example, between the respective B plats, maintained at a moisture content of 16 per cent, and the total precipitation for the period from October to March, inclusive, is represented by the correlation coefficient −0.86. On the other hand, the coefficient between the amount of water applied to these plats and the rainfall during the growing season, April to August, inclusive, is zero, while little or no relation appears to exist between the irrigation water applied in winter and that required during the growing season.

As indications of these relations and lack of relations the following data may be considered: The total winter rainfall October to March, inclusive, for the respective years was 1914–15, 5.5 inches; 1915–16, 3.7 inches; 1916–17, 2.1 inches; 1917–18, 3.8 inches; 1918–19, 9.7 inches. The corresponding summer rainfalls were 18.4, 11.5, 13.2, 9.4, and 8.0. The amount of summer irrigation required to maintain the milo plat at 16 per cent moisture content was 3.4, 9.1, 13.4, 8.8, and 2.6, respectively. It will be noted that for the year 1918–19 when the fall and winter precipitation was 9.7 inches the C plats required no summer irrigation and 2.6 inches were all that was necessary to maintain the B plats at 16 per cent moisture content for milo. On the other hand, the year preceding had only 3.8 inches of winter precipitation, but at the same time 12.7 inches were added by winter irrigation, making a total of winter water of 16.5 inches. In this case, it required 5.9 inches of summer irrigation to maintain the C plats against none for the preceding year and 8.8 inches to keep the B plat supplied with the required moisture against 2.6 for the succeeding year. This would appear to indicate that the winter irrigation had little effect on the summer requirements when compared with the winter precipitation. A much longer series of observations will be required, however, before trustworthy conclusions can be drawn in this connection.

In summing up the results of his experiments, Mr. Knapp presents the following conclusions:

The amount of water required to keep the soil moisture content at a given per cent of saturation varies somewhat with the kind of crops grown.

Crops differ greatly in the amounts of water which they can profitably use, and in the range of yield which can be effected by applying various amounts of water.

Milo shows a marked ability to increase in yield of grain as additional amounts of water are applied, and where the crop receives sufficient irrigation water it is affected less by unfavorable climatic conditions than the other crops included in this experiment. The yield of stover was not greatly influenced by increasing the amount of water.

Kafir exhibits much the same characteristics as milo, but is unable to respond to the application of water to the same extent as milo, so far as this is measured by the yield of grain.

Sumac sorgo was not able to use economically large amounts of water, and showed a slight falling off in yield of stover when more than about 15 inches was applied.

Sudan grass grown in rows for seed is not a profitable irrigation crop, and when it is so grown it should not be irrigated heavily.

The yields of small grain crops such as wheat, oats, and barley are controlled to a greater extent by prevailing weather conditions than by available amounts of water, and no amount of water has sufficed to insure good yields in years of adverse weather conditions.

THE WEATHER OF 1922.

By A. J. HENRY.

Cyclones and anticyclones.—The number of cyclones (189) and of anticyclones (129) which appeared within the field of observation during the year was considerably in excess of the 20-year average. That fact, however, does not necessarily indicate a year of greater storminess as some writers claim. The word "storminess" is, at best, a vague term when applied to average conditions unless the writer indicates clearly what is meant. The suffix "ness," added to the root "stormy," must mean, at least, greater violence of the winds, an increased amount of both cloudiness and precipitation. All of these characteristics are amenable to exact observation and tabulation and it is an easy matter to ascertain whether or not any given period has been one of strong winds, great precipitation, and naturally much cloudiness. The record of cyclones for the year very clearly shows that increased storminess can not be predicated upon a large number of cyclones. The important point to be remembered is that quality rather than quantity is the determining factor.

Precipitation.—Considering the United States as a single geographic unit its weather during 1922 may be briefly characterized as warm and moderately dry. More rain fell than in 1921, but the distribution throughout the year was very uneven. After a rainy spring and early summer, a shortage of rain was felt in more or less restricted areas in Atlantic Coast States, the Ohio Valley, and portions of the Plains States. The monthly distribution by climatological districts is shown in Table 1 and the departures from normal on chart A. J. H. II. This shortage continued, mostly in eastern districts, throughout November, and by that time the